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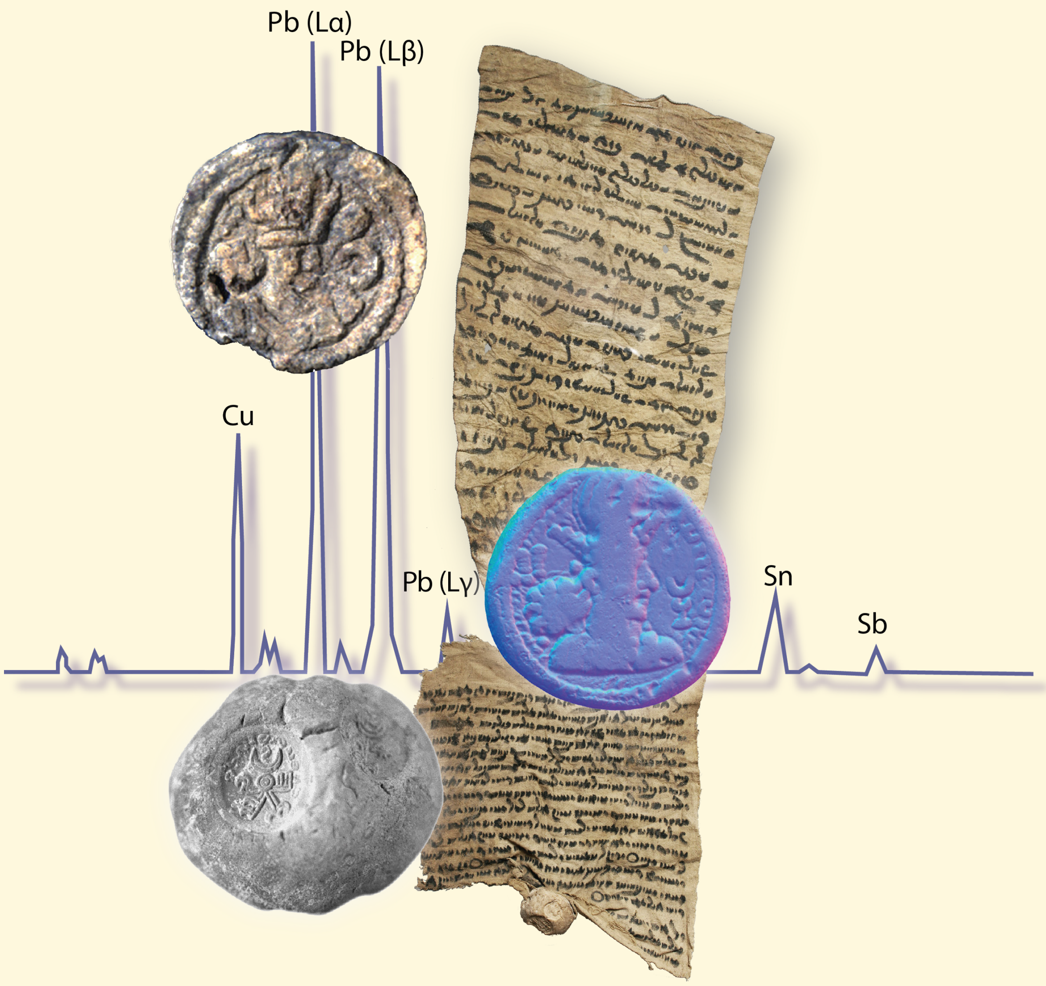

SASANIAN COINS, MIDDLE-PERSIAN ETYMOLOGY AND THE TABARESTĀN ARCHIVE

— EXTRAIT —

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APPENDIX: THE INTERACTIVE 2D+ IMAGES OF THE BRUSSELS SASANIAN COINS

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The representations of the Sasanian coins published in "Une collection de monnaies sassanides de billon, de cuivre et de plomb" by Rika Gyselen & Malek Iradj Mochiri are all based on images made with the so-called Portable Light Dome (PLD) system (Willems *et al*. 2005; Hameeuw & Willems 2011; Hameeuw 2011), a multi-light/directional reflectance technique. With this method both sides of each coin have been imaged, A. to facilitate their study, B. to digitally safeguard them for curatorial purposes and C. to allow researchers to publish adequately those visualisations of the coin's surface they selected in support to their study and findings. Figure 1 demonstrates how some different types of archaeological surfaces from the ancient Near East can be visualized with this system.

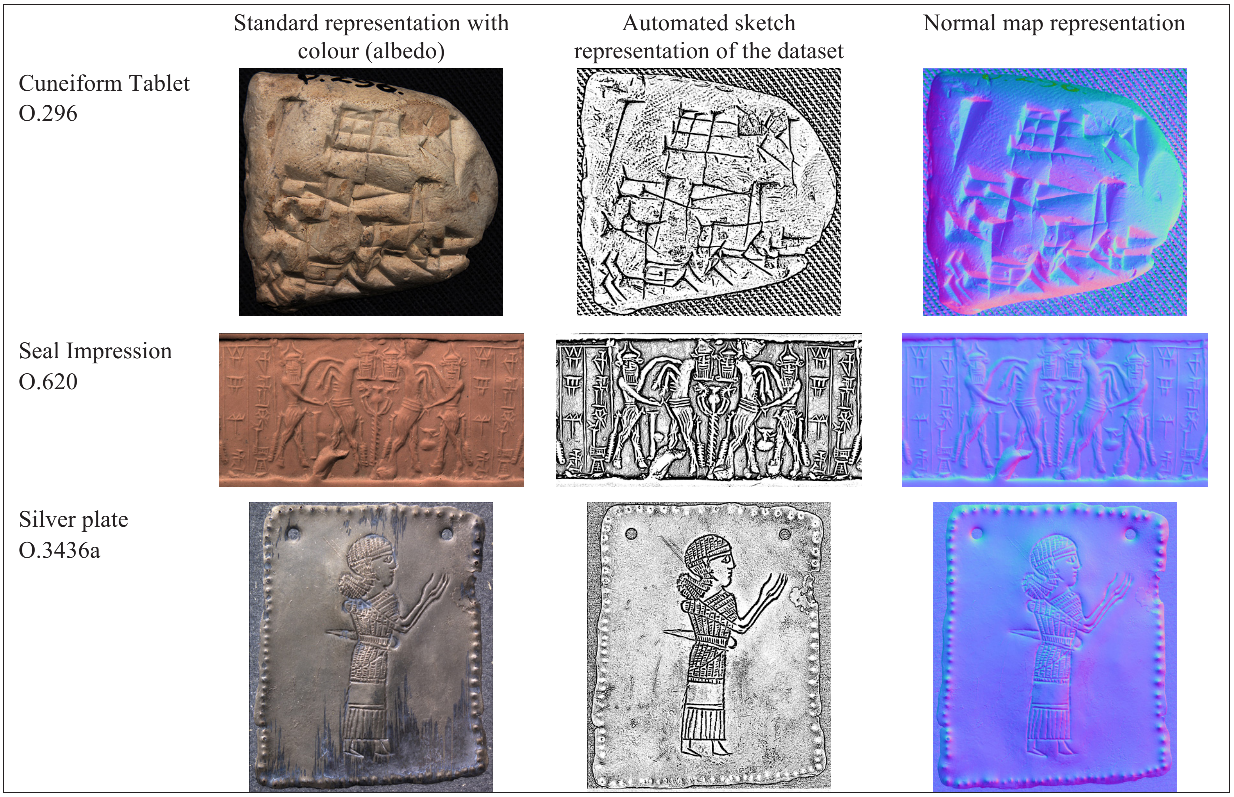


Fig. 1 – Examples of various visualisations of a selection of object types (© KMKG-MRAH, Brussels).

As ancient coins are relatively small disk shaped objects with a shallow relief as their main physical characteristic, and for which each specimen finds itself in a particular state of deterioration, only well executed imaging technique can permit a sufficient visual outreach for this type of artefacts. The automatic acquisition system of the PLD photographs the surface of a coin under 260 different lighting condition; on each produced picture the lighting angle which falls on the surface has been changed. After the acquisition, in a second step, all this information is computed into one interactive visualization including both sides of each coin. The result resembles a normal photograph, but in fact, the virtual dataset conceals enhanced information based on the algorithms which have established for every pixel in the image its reflection values (colour and texture) and the surface orientation (normal); this approach is called photometric stereo. The latter even allows reconstructing the surface in three dimensions (Fig. 2g).[1] Recently, several coin collection have been digitally registered, studied and published with the help of similar multi-light/directional reflectance techniques (Mudge *et al.* 2005; Hameeuw 2011; Palma *et al.* 2013; Kotoula & Kyranoudi 2013).

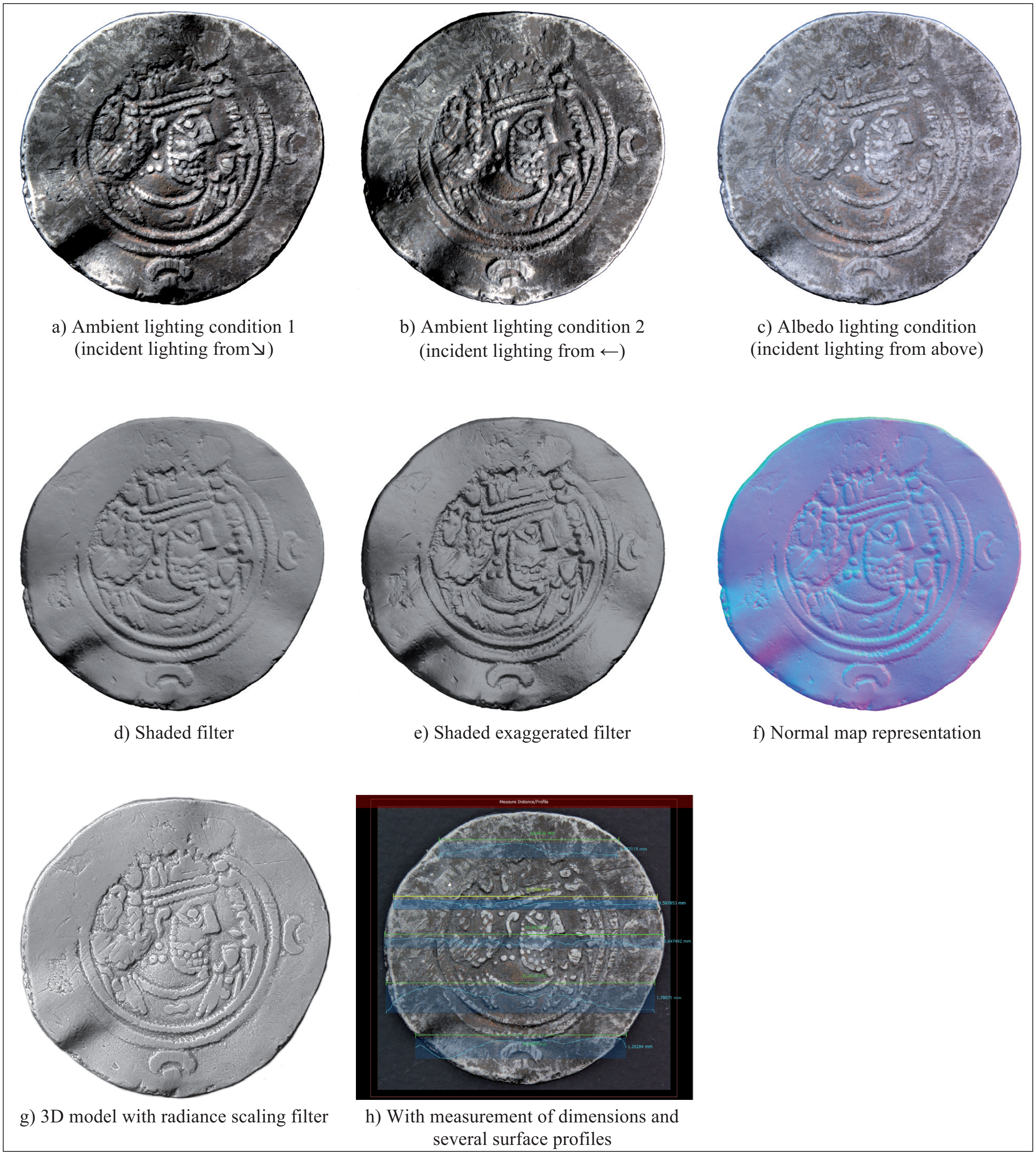
Thus, for each recording the obtained datasets can be visualized in various manners. For the Sasanian coin publication two types of visualisations were selected to include both a photorealistic representation and an image that provides maximal information on the geometry of the coin's surfaces. The former consist of a colour image on which the system has simulated a particular reflection condition (Ambient or Albedo). Depending on the nature of the metal alloy of the coins and their state of preservation, their surfaces will reflect light differently. By giving a researcher the ability to switch between and select various virtual lighting conditions certain features can be visualised better and more accurately. Beside the manner in which the general lighting condition is calculated, the PLD system can – as all multi-light/directional reflectance viewing systems – also virtually simulate how the surface reflects when light drops on it coming from innumerable different angles. Again, this interactive approach allows the researcher to produce the best suitable representation of a coin in support to the executed study. In fig. 2, images a-c demonstrate such altered photorealistic visualizations. In the main text of the here presented publication where the Sasanian coins are discussed, it are these colour (or textured) images which are being used as illustrations in a scale 2:1; in the catalogue they are represented in a scale 1:1.

1 Research financed and supported by the Belgian Science Policy Office-Belspo, Interuniversity Attraction Poles Programme IAP 7/14: Greater Mesopotamia.

An important remark towards these photorealistic colour representations is that they are not photo graphs that visualize a surface as light has reflected on it and how it would appear to the human eye. Photographs of metal objects will for example give glossy reflections, some clusters of pixels will appear white. In fig. 2a-c, the photorealistic images of the PLD system do not show this effect; on the contrary, they estimate how every pixel would reflect without these so-called specular highlights. As a consequence, the colour images presented in this publication have an overall pale appearance. The benefit is, that none of the pixels is obscured by these specular highlights and provide in one and the same representation all potential information, which can be extracted based on a colour image. By dropping one or various virtual lighting angles on the surface any desired features can be emphasized.

The surface of a coin is in the first place characterized by its shallow relief, so by its tangible geometrical features. With the outcome of the multi-light/directional reflectance method of the PLD system the orientation of every pixel is estimated with a high accuracy. So when the colour or texture of the surface is omitted, only the geometric features appear (Fig. 2d-e), which makes many details better identifiable. For the plates of the catalogue in this publication it was chosen to use the 'normal map' visualisations of the obtained coin datasets on scale 2:1. In these blueish images each pixel has been attributed a shade of blue, green or red, corresponding to their orientation in a x, y, z environment; so they visualize 3D information in a flat 2D representation (Fig. 2f). Throughout the research phase of the Sasanian coins these normal maps have proven their value during the identification of otherwise difficult to interpret features; good examples are IR.3753-0047 and IR.3753-0073.

An additional benefit of the interactive PLD images is that beside pure visual enhancements of the coins, the surfaces can also be investigated based on mathematical data. The photometric stereo approach has established pixel per pixel the geometry of the surface and before the acquisition was initiated, the scale of the image has been calibrated up to 10-100 µm; thus, a height profile can be calculated for every section and detail on the coin's surface (Fig. 2h). The yellow/green lines give the linear measurements, the blue lines render the surface profile along that yellow/green line.



a) Ambient lighting condition 1 (incident lighting from ↘)

b) Ambient lighting condition 2 (incident lighting from ←)

c) Albedo lighting condition (incident lighting from above)

d) Shaded filter

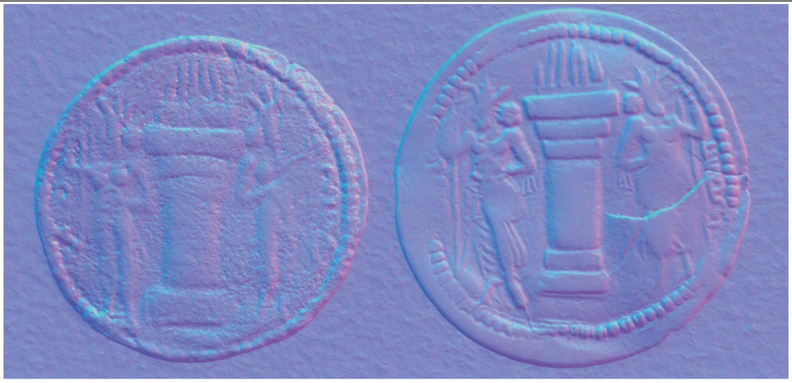
e) Shaded exaggerated filter

f) Normal map representation

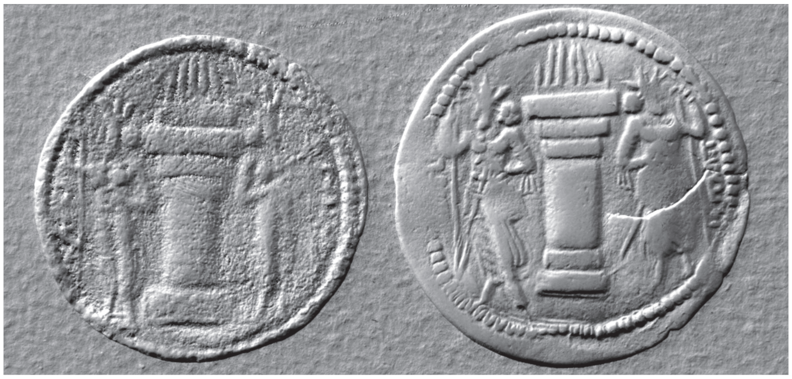
g) 3D model with radiance scaling filter

h) With measurement of dimensions and several surface profiles

Fig. 2 – Various visualisations based on one imaging exercise with the Portable Light dome of the obverse of lead coin IR.3753-172 (© KMKG-MRAH, Brussels).



a) Normal map representation



b) Shaded filter

c) Ambient lighting

Fig. 3 – Different materials and states of conservation as imaged by the PLD system: Reverse of IR.3753-0185, an Æ alloy & IR.3753-0186, a billon (potin) alloy (© KMKG-MRAH, Brussels).

As for conventional photography the PLD system creates images based on the reflective properties of a surface detected by a camera (light sensor). But, when the material of the artefact absorbs most of the light, its surface will appear dark which obscures the details. For such coins the photometric stereo algorithms will have more difficulty to estimate accurately the colours and surface orientations per pixel. With deteriorated surfaces similar hazards emerge. A well preserved coin has a smooth surface which immediately reflects most of the light; the more this smoothness is affected by aging, this results in a more porous surface layer. The light will penetrate into that layer and might reflect multiple times in that layer before it reflects in the direction of the camera. That effect will as well make it more challenging for the photometric stereo algorithms in the PLD system to estimate the correct colours and surface orientations per pixel. Figure 3 demonstrates how the final results are affected when dark and deteriorated surfaces are imaged. To the right, the PLD system imaged a well preserved billon coin with a smooth surface on which the incident light shows a well definable reflection behaviour. As a consequence, the normal map of this coin gives a very accurate reconstruction of the surface orientations; as well for the representation of the colour version no inaccuracies can be spotted. The coin to the left, a more dark appearing Æ alloy, has a surface affected by the elements, which gives it a poriferous nature. The incident light has reflected in a more complex manner on/in this surface which led to a less well defined estimation of both the colour and surface orientations. This clarifies the difference in quality between some of the produced PLD images included in this publication

Lastly, throughout the research phase it were the interactive datasets which were used for the study and identification of the Sasanian coins. These datasets could be consulted in a custom-made viewer interface: PLDviewer 5.0.04. With this software the researcher can switch from one enhancement filter and visualisation mode to the other, all performed instantly and in real-time. It must be stressed that the static representation in the present publication are withdrawn from this benefit.

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